

REMARKS

Claims 1 to 16, as amended, appear in this application for the Examiner's review and consideration. Claims 13 to 16 have been withdrawn from consideration, as being drawn to non-elected subject matter. Claims 1-12 are currently rejected. Claims 3 and 5 have been cancelled. Claim 1 has been amended, support for the amendment can be found in the specification on page 4, line 32 to page 5, line 3 and claim 5 as originally filed. Claims 6 to 8 have been amended merely to maintain proper dependency. Claim 10 has been amended merely to maintain proper antecedent basis and claim 11 has been amended to merely correct a grammatical error.

1. Objection to claims 3 and 9.

The Examiner objects to claim 3 under 37 CFR 1.75(c), as being of improper dependent form for failing to further limit the subject matter of a previous claim. According to the Examiner claim 3 is identical to claim 1 from which it depends. Applicant has cancelled claim 3, accordingly the objection is now moot.

The Examiner objects to claim 9 because of an informality in the term "compared to a fuel arrangement from pure uranium dioxide" which according to the Examiner should read "compared to that of a fuel arrangement from pure uranium dioxide." Applicant submit that this term is not in claim 9 but in claim 11 and has amended claim 11 accordingly.

Therefore, withdrawal of the objections to claim 3 and 9 are respectfully requested.

2. Rejection of Claim 11 Under 35 U.S.C §112 First Paragraph

The Examiner has rejected claim 11 under 35 U.S.C. §112, first paragraph, as allegedly lacking enablement. According to the Examiner, the specification, while enabling for increased thermal conductivity of 50% for a 10% volume loading of silicon carbide, does not reasonably provide enablement for at least 5% increase compared to that of a fuel arrangement from pure uranium dioxide. In response, Applicant submits that the specification describes that the treatment process of incorporating a precursor liquid in the uranium oxide nuclear fuel increases the thermal conductivity of the uranium dioxide fuel. In addition, the thermal treating process is repeated, when desired, to allow more incorporation of precursor liquid, as taught in the specification on page 5, second paragraph. The specification also describes on page 6, as the Examiner noted, that thermal conductivity of

uranium dioxide fuel is increased by the presently claimed treatment, for example by 50% for a 10% volume loading of silicon carbide, thus at least 5%. Therefore, the skilled artisan would know how to make use of the claimed invention by thermally treating the uranium oxide fuel, infiltrated with a precursor liquid, as clearly described in the specification, to obtain an uranium oxide fuel having at least an increase of 5% in thermal conductivity, as in original claim 11, by repeating, if required, the claimed thermal treating process. To determine whether a 5% increase in thermal conductivity is achieved by the claimed process requires only routine experimentation of the conductivity of the obtained uranium dioxide fuel. Therefore, the skilled artisan is clearly taught how to make use of the claimed invention of increasing the thermal conductivity of the fuel arrangement to at least 5% as compared to that of a fuel arrangement formed from uranium dioxide. Accordingly, claim 11 is enabled by the specification and withdrawal of the rejection of claim 11 under 35 U.S.C. §112, first paragraph is respectfully requested.

3. Rejection of Claim 11 Under 35 U.S.C §112 Second Paragraph

Claim 11 is rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter. According to the Examiner the meaning of the term “pure uranium dioxide” is unclear. In response, Applicant submits that the specification describes that the claimed process provides increased thermal conductivity compared to conventional nuclear fuel. Conventional nuclear fuel is further characterized as uranium dioxide in unmodified form as described on page 1, lines 24 to 27. For this reason, Applicant submits that the term “pure uranium dioxide” is clearly described as conventional uranium dioxide which is in unmodified form and the skilled artisan reading the specification would understand the term “pure uranium dioxide” to mean such unmodified uranium dioxide. Accordingly, withdrawal of the rejection of claim 11 for being indefinite under 35 U.S.C. §112, second paragraph, is respectfully requested.

4. Rejection of claim 1, 3-4, 9, and 12 under 35 U.S.C. 102(b).

Claims 1, 3-4, 9, and 12 were rejected by the Examiner as allegedly anticipated by Feraday (US 4,020,131), GB1228317, and by Lee (US 4,110,159). The Examiner asserts that each of these three references disclose a method of producing uranium dioxide fuel comprising providing a (“green”) pellet/compact porous body of uranium dioxide (claimed porous UO₂ pellet), impregnating the pellet/porous body with a solution of plutonium nitrate

(claimed infiltrating with precursor liquid) and heating the impregnated pellet to convert the precursor into plutonium oxide (claimed second phase).

In response, Applicant submits that independent claim 1, as amended, requires that thermal treatment comprises the steps of curing and then firing the infiltrated uranium dioxide arrangement. The cited references (Feraday, GB1228317, and Lee) all disclose converting plutonium nitrate to plutonium oxide or an additive such as Boron or Gadolinium to a metal alloy by heating the nuclear fuel arrangement to obtain a MOX fuel (composed of oxides of uranium and plutonium) or a poisoned fuel by the addition of a neutronic poison as boron or gadolinium oxide, a process that does not include a curing step. Thus, the required claim element of the curing step of the infiltrated uranium dioxide arrangement in independent claim 1, is not taught in the methods of the cited references. Therefore, independent claim 1, as amended is not anticipated by the above cited references. Claims 4, 9, and 12 depend from claim 1, and therefore are also not anticipated. Accordingly, withdrawal of the rejection under 35 U.S.C. 102(b) of claims 1, 3-4, 9, and 12, as anticipated by Feraday, GB1228317, and Lee is respectfully requested.

5. Rejection of Claims 1, 3-9, and 11-12 under 35 U.S.C. §103(a)

Claims 1, 3-9, and 11-12, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over GB1035789 in view of Carley-Macauley et al (US 3164487). According to the Examiner, GB '789 discloses a method of producing a nuclear fuel body, uranium carbide, with very low permeability to gases comprising impregnating a porous body comprising nuclear fuel element with a polymerizable substance such as furfuryl alcohol, by immersing nuclear fuel body in a bath of the polymerizable substance, curing, and carbonizing the cured substance. Further, the Examiner asserts that Carley-Macauley et al disclose that uranium oxide or uranium carbide can be used as a nuclear fuel.

In response, Applicant submits that independent claim 1, as amended, relates to a method of preparing an uranium dioxide fuel, comprising: providing a porous uranium dioxide arrangement; infiltrating the porous uranium dioxide arrangement with a precursor liquid; and curing and thermally firing the porous uranium dioxide arrangement with the infiltrated precursor liquid such that the precursor liquid is converted to a second phase.

GB '789 is directed to a method of preparing a solid fuel body, by impregnating pores of the fuel body with a polymerizable substance, and curing and carbonizing the substance to reduce the gas permeability of the fuel body. The fuel body in the GB '789 patent, which is a

high temperature reactor fuel, comprises a graphite matrix and dispersed therein nuclear fuel particles, each of which is encased in a protective pyrolytic carbon coating. In contrast to a porous nuclear fuel which is being impregnated with a polymerizable substance, it is the porous graphite matrix, a non metallic material, which contains protectively coated nuclear fuel particles that is being impregnated with a polymerizable substance in the method disclosed in GB'789. Carley-Macauley et al disclose a method of pyrolytically carbonizing a nuclear fuel body, which comprises particles of a metal oxide or carbide, by impregnating the nuclear fuel body with a gas, not a liquid precursor. The gasses used in the process are chosen such that polymerization is less likely as disclosed in column 4, lines 30 to 38. These impregnated gasses are carbonized in the process of Carley-Macauley et al, again not disclosing a curing of the impregnant.

Therefore, Applicant respectfully submits that GB '789 fails to teach or suggest to use a porous uranium oxide nuclear fuel and infiltrating it with a liquid precursor, which is subsequently thermally treated by first curing and then firing the uranium dioxide arrangement, as in the presently claimed invention. As discussed, GB'789 teaches a method of impregnating pores of the fuel body with a polymerizable substance, and curing and carbonizing the substance to reduce the gas permeability of the fuel body not a porous uranium dioxide arrangement. In fact, GB '789 teaches away from using porous uranium dioxide as it teaches the use of nuclear fuel particles in a protective coating which particles are dispersed in a porous graphite matrix. The nuclear fuel particles therefore cannot be infiltrated with a liquid precursor as in the presently claimed invention. This failure in the disclosure of GB '789 is not cured by the disclosure of Carley-Macauley et al teaching a method of pyrolytically carbonizing a nuclear fuel body. The treatment of pyrolytically carbonizing a nuclear fuel body is very different from the thermal treatment of the presently claimed method of curing and then firing an infiltrated uranium dioxide arrangement. Moreover, Carley-Maceuley et al teach the use of suitable gasses in their method of pyrolytically carbonizing a nuclear fuel body which are less likely to polymerize, effectively teaching away from the curing step required in the presently claimed invention. For these reasons, GB'789 and Carley-Macauley teach away from the claimed invention and even when combined the GB'789 patent in combination with Carley-Macauley et al does not teach or suggest a method of providing a porous uranium dioxide, infiltrating the uranium dioxide with a liquid precursor and curing and firing the infiltrated uranium dioxide to obtain uranium dioxide with a second phase as presently claimed. Accordingly, claim 1, as amended, and

claims 4, 6-9, and 11-12, dependent thereon, are non-obvious over GB '789 in view of Carley-Macauley et al, and withdrawal of the rejection is respectfully requested.

6. Rejection of Claims 1, 3-9, 11-12 under 35 U.S.C. §103(a).

Claims 1, 3-9, and 11-12, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over Carley-Macauley et al in view of Nicholson et al (US 3,035,325) and Mysels (US 4,073,834). According to the Examiner, Carley-Macauley et al disclose a method of producing carbon-impregnated nuclear fuel with very low permeability to gases by pyrolysis of methane and other hydrocarbons. The Examiner further asserts that although Carley-Macauley et al fail to teach an impregnation with a liquid precursor Nicholson et al disclose impregnation of a porous body with a resinous solution or furfural followed by carbonization. According to the Examiner, Nicholson teaches an impregnating technique for depositing carbon in the pores of substantially any refractory body having an intercommunicating network. Moreover, according to the Examiner, Mysels teaches that carbon can be deposited in the pores in a fuel arrangement by first curing a prepolymer and then decomposing the cured polymer and carbonizing the material at 1200°C or higher.

As described above, Applicant submits that independent claim 1, as amended, relates to a method of preparing an uranium dioxide fuel, comprising: providing a porous uranium dioxide arrangement; infiltrating the porous uranium dioxide arrangement with a precursor liquid; and curing and thermally firing the porous uranium dioxide arrangement with the infiltrated precursor liquid such that the precursor liquid is converted to a second phase. Carley-Macauley et al discloses a method of pyrolytically carbonizing a nuclear fuel body, which comprises particles of a metal oxide or carbide, by impregnating the nuclear fuel body with a gas, not a liquid precursor. The gasses used in the process are chosen such that polymerization is less likely as disclosed in column 4, lines 30 to 38. These impregnated gasses are carbonized in the process of Carley-Macauley et al, again not disclosing a curing of the impregnant.

Further, Nicholson et al discloses methods of making silicon carbide bodies from silicon nitride, a solid. The silicon carbide bodies are prepared by rapidly heating silicon nitride to above 1900°C in the presence of a carbide, which process may be preformed in a refractory body. In Nicholson et al, impregnating techniques using a liquid precursor are only disclosed to deposit carbon in silicon carbide bodies. The silicon carbide bodies

prepared by the method disclosed in Nichols et al are not nuclear fuel bodies, let alone porous uranium dioxide nuclear fuel. Mysels discloses a method of preparing a nuclear fuel element by impregnating a porous graphite block containing nuclear fuel chambers with a carbonizable impregnant which penetrates the fuel chambers. The fuel chambers contain nuclear fuel material which is coated with (dense) pyrocarbon. The impregnant in the fuel chambers is then cured and carbonized to provide a carbon residue which binds the nuclear fuel material to the graphite block/body, preparing a high temperature reactor fuel.

Therefore, Applicant respectfully submits that Carley-Macauley et al do not disclose the claimed method of infiltrating a liquid precursor material in a porous uranium dioxide and curing and firing the infiltrated porous uranium dioxide to obtain a second phase within the uranium dioxide arrangement. The method of Carley-Macauley et al impregnated a nuclear fuel body with a gas, not a liquid, to carbonize the porous nuclear fuel body. Carley-Macauley fails to teach infiltrating a liquid precursor material which is thermally treated by curing and then firing to form a second phase in an uranium dioxide nuclear fuel arrangement. Moreover, as discussed above Applicant submits that Carley-Macauley et al effectively teach away from curing a porous uranium dioxide infiltrated with a liquid precursor. Nicholson et al and Mysels do not cure this failure, and thus Carley-Macauley et al in combination with Nicholson et al and Mysels does not teach or suggest the claimed method in independent claim 1, as amended. In fact, Nicholson et al is drawn to a method of preparing silicon carbide bodies, not nuclear fuel bodies. Therefore, there is no motivation to combine the teachings of Carley-Macauley et al with Nicholson et al. In addition, Mysels does not teach or suggest infiltrating a porous uranium dioxide nuclear fuel material and curing and carbonizing a porous uranium dioxide as it is drawn to impregnating a porous graphite block which contains protectively coated nuclear fuel material, effectively teaching away from infiltrating a porous nuclear fuel material with a liquid precursor material. Moreover, Mysels teaches a method of carbon binding a coated nuclear fuel material to a graphite block/body in contrast to infiltrating porous nuclear fuel material such as porous uranium dioxide.

For these reasons, there is no motivation to combine the teachings of Carley-Macauley et al with Nicholson et al and Mysels, the method of Nicholson et al directed to processes of preparing silicon carbide bodies and Carley-Macauley et al and Mysels directed to preparing nuclear fuel bodies. Further, even in combination Carley-Macauley et al in view of Nicholson et al and Mysels do not teach or suggest for the reasons stated above, the

claimed method of infiltrating a porous uranium dioxide nuclear fuel material with a liquid precursor material and thermally treating the infiltrated uranium dioxide to obtain a second phase in the uranium dioxide by first curing and then firing the uranium dioxide arrangement as in independent claim 1, as amended. Accordingly, withdrawal of the rejection of claim 1, as amended, and claims 4, 6-9, and 11-12 dependent thereon, as obvious under 35 U.S.C. 103(a) over Carley –Macauley et al in view of Nicholson et al and Mysels is respectfully requested.

7. Rejection of Claims 2 and 10 under 35 U.S.C. §103(a).

Claims 2 and 10, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over GB1035789 in view of Carley-Macauley et al/Carley-Macauley et al in view of Nicholson et al and Mysels/, and further in view of Burnham et al (US 3,129,141) and Chayka (US 5,952,046). The Examiner refers to the assertions made with respect to claims 1, 3-9, and 11-12 over the cited references and asserts that Burnham et al teaches that silicon carbide may be used for making a dense body of a nuclear fuel element. Moreover, although the cited references fail to teach that silicon carbide is impregnated from a polymerizable allylhydridopolycabosilane (AHPCS), according to the Examiner Chayka teaches that liquid AHPCS is a commercially known silicon carbide source.

As described above, Applicant submits that independent claim 1, as amended, relates to a method of preparing an uranium dioxide fuel, comprising: providing a porous uranium dioxide arrangement; infiltrating the porous uranium dioxide arrangement with a precursor liquid; and curing and thermally firing the porous uranium dioxide arrangement with the infiltrated precursor liquid such that the precursor liquid is converted to a second phase. Further, as also described above, GB '789 in view of Carley-Macauley et al does not teach or suggest, nor is there motivation to combine Carley-Macauley et al with Nicholson et al and Mysels to teach or suggest the method of independent claim 1, as amended, of infiltrating porous uranium dioxide with a liquid precursor material and thermally treating the infiltrated uranium dioxide to obtain a second phase by first curing and then firing the infiltrated uranium dioxide arrangement. These references, alone or in combination, teach methods of carbonizing porous nuclear fuel bodies/elements by impregnating such porous nuclear fuel body with a precursor material that is carbonized to obtain a high temperature reactor fuel, but fail to disclose infiltrating porous uranium dioxide nuclear fuel with a liquid precursor material and curing the liquid precursor infiltrate within the uranium dioxide arrangement.

Burnham et al is directed to a method of preparing a nuclear fuel element comprising a dense body of uranium carbide, graphite, silicon carbide and silicon. The uranium carbide is in the form of carbon coated uranium particles. In the method of Burnham et al, these particles are mixed, either alone or preferably with silicon carbide, with suitable resin binder, then pressed in a shape and the resin is cured. This material is then immersed in molten silicon during which the resin carbonizes and reacts with the silicon to form silicon carbide. The material obtained by the process of Burnham et al therefore is a silicon carbide as base material and incorporated therein the nuclear fuel material as described in column 1, lines 23-29. Burnham et al does not teach or suggest infiltrating porous uranium dioxide with a liquid precursor material. Chayka is directed to the chemical vapor deposition of silicon carbide or carbide on substrates, and does not teach infiltrating and curing a liquid precursor in a nuclear fuel body or material.

For the reasons stated above, Applicant submits that GB'789 in view of Carley-Macauley and Carley-Macauley in view of Nicholson et al and Mysels fail to teach infiltrating a porous uranium dioxide fuel material with a liquid precursor to obtain an uranium dioxide arrangement containing a second phase silicon carbide. The disclosure of Burnham et al and Chayka do not cure this failure. In fact, Burnham et al disclose using uranium carbide nuclear fuel which is protectively coated with graphite/carbide, effectively teaching away from infiltrating a porous uranium dioxide nuclear fuel with a precursor liquid as in presently independent claim 1, as amended, from which claims 2 and 10 depend. Moreover, the disclosure in Burnham et al teaches impregnating a porous nuclear fuel body, not a nuclear fuel uranium dioxide arrangement. Accordingly, the cited references further in view of Burnham et al, even if combined, fail to suggest the presently claimed method. Further, Chayka, directed to a method of chemical vapor deposition, also fails to teach a method of infiltrating and curing a liquid precursor into an uranium dioxide arrangement.

Thus, the cited references fail to teach or suggest the presently claimed method as in independent claim 1, as amended, let alone the methods of claims 2 and 10, which depend thereon, claim 2 relating to the method of claim 1, wherein the liquid precursor material is defined as AHCP, claim 10 which relates to the method of claim 1, wherein the second phase is solid silicon carbide. Accordingly, withdrawal of the rejection of claims 2 and 10 under 35 U.S.C. 103(a) as obvious in view of the cited references is respectfully requested.

8. Rejection of Claim 11 under 35 U.S.C. §103(a).

Claim 11, was rejected under 35 U.S.C. §103(a) as allegedly being obvious over Carley-Macauley et al in view of Nicholson et al and Mysels, and further in view of GB '789. The Examiner refers to the assertions made with respect to claims 1, 3-9, 11-12 over Carley-Macauley et al in view of Nicholson et al and Mysels and asserts that GB '789 discloses that the desired low gas permeability is achieved by repeating the steps of impregnating, curing and carbonizing.

According to substantially the same reasoning as applied above submitting that claims 1, 3-9 and 11-12 are non-obvious over Carley-Macauley et al in view of Nicholson et al and Mysels et al, Applicant submits that claim 11 is non-obvious over these reference in further view of GB'789. The cited references fail to teach or suggest, either alone or in combination the claimed method as in independent claim 1, as amended, from which claim 11 depends. In fact, as described above there is no motivation to combine the cited references and Mysels et al effectively teaches away from infiltrating porous uranium dioxide. This failure in the disclosures of Carley-Macauley et al, Nicholson et al and Mysels, even when they are combined, is not cured by the disclosure of the GB'789 patent as described above when discussing the GB'789 patent in view of claim 1, 3-9, and 11-12. Although the GB'789 patent teaches to repeat a process of impregnating, curing and carbonizing a porous nuclear fuel body, having dispersed within its matrix nuclear fuel material, with a polymerizable substance until a desired level of gas impermeability, it does not teach or suggest in combination with the other references cited the method of claim 11. GB'789 as discussed above is directed to impregnating a porous nuclear fuel body comprising protectively coated nuclear fuel particles with a polymerizable substance, which is then carbonized. Again, the GB'789 patent teaches the use of protectively coated nuclear fuel particles, effectively teaching away from the use of porous uranium dioxide as presently claimed. Therefore, withdrawal of the rejection of claim 11 under 35 U.S.C. 103(a) as obvious in over Carley-Macauley et al in view of Nicholson et al and Mysels in further view of GB'789 is respectfully requested.

9. Conclusion

Applicant thus submits that the entire application is now in condition for allowance, an early notice of which would be appreciated. Should the Examiner not agree with Applicant's position, a personal or telephonic interview is respectfully requested to discuss

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any remaining issues prior to the issuance of a further Office Action, and to expedite the allowance of the application.

Respectfully submitted,

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